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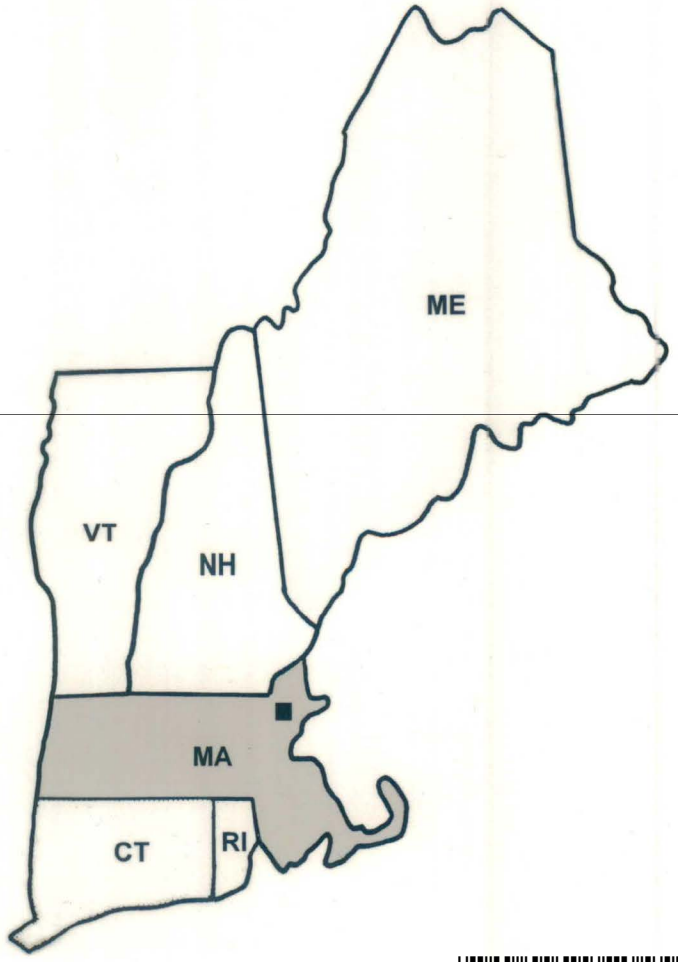
HISTORICAL AERIAL PHOTOGRAPHIC ANALYSIS, LAND USE/LAND COVER ANALYSIS, SITE DISCOVERY INVENTORY ANALYSIS, WETLANDS/DRAINAGE ANALYSIS, AND FRACTURE TRACE ANALYSIS OF OLIN CHEMICAL SUPERFUND SITE

Wilmington, Massachusetts

Volume 1

EPA Region 1



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Wilmington, Massachusetts

Volume 1

by

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NOTICE

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ABSTRACT

This report presents the results of five aerial photographic analyses of the former Olin Chemical Superfund site located near Wilmington, Massachusetts. These analyses include a historical photographic site analysis, a land use/land cover analysis, a site discovery inventory analysis, a wetlands/drainage analysis, and a fracture trace analysis. This report is presented in two volumes, one which presents the text descriptions and analyses, the second the aerial photographs and interpretive overlays.

The Olin Chemical Superfund site covers approximately 20 hectares (50 acres) in a commercial/industrial zoned area approximately 1.6 kilometers (1 mile) south of Wilmington, Massachusetts. The site is bounded to the north by Eames Street, to the east and west by railroad tracks, and to the south by the Woburn corporate boundary. The region has gently rolling terrain and a shallow groundwater level such that wetlands are observed to the north, east, south, and west of the site.

Of specific interest to the Region 1 Office of the U.S. Environmental Protection Agency (EPA) are sources and pathways for potential contaminants entering the natural drainage system, especially the wetland system and aquifer associated with Maple Meadow Brook, which until 2003 was used as the primary water supply source for the town of Wilmington. These analyses, funded under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), were prepared to determine potential sources and pathways of pollutants threatening the natural drainage system and drinking water supplies. The report will aid EPA field investigators to develop field sampling strategies.

For the historical photographic site analysis seventeen dates of aerial photographs, spanning the period 1952 through 2004, were reviewed

and ten dates were selected for inclusion in this report. The findings of the historical photographic analysis site show that the Olin Chemical Superfund site, which was active by 1960, operated numerous processing/storage tanks, processing buildings, a drum handling area, and liquid waste ponds/pits. Various waste pits, ponds, lagoons, and landfill areas were operated over the life of the chemical plant. By 1978 a landfill had been established in the southwestern corner of the site. The landfill was closed and recontoured by 1991. By 1991 several buildings and structures at the site were dismantled and two lagoons had been closed and buried. By 2004 a large containment area had been constructed across an area formerly occupied by two lagoons that had been closed by 1991.

The land use/land cover, site discovery inventory, and wetlands/drainage analyses were conducted for a study area that surrounds the Olin Chemical Superfund site. This study area is bounded to the east by Interstate 93, to north by Butters Row Road and Lowell Street, to the west by Chestnut Street, and to the south by Merrimac Street. The land use/land cover, site discovery inventory, and wetlands/drainage analyses were performed using historical aerial photography dated 1960 and 2004.

Findings of the land use/land cover analysis determined that in 1960 the study area consisted of residential land, commercial and industrial land, wooded land with wetlands and ponds/lakes, agricultural land, and transitional land. By 2004 the both commercial land use and residential land use had significantly increased while agricultural land and wooded land had significantly been reduced.

The findings of the site discovery inventory analysis for the period 1960 and 2004 revealed the predominant development was in commercial retail, warehousing, and commercial services. Two large landfill operations were observed over the period 1960 through 2004.

Findings of the wetlands/drainage analysis, conducted using 1960 and 2004 aerial photographs, indicated that the largest extent of wetlands within the study area located west of the Olin Chemical Superfund site along Maple Meadow Brook. The Maple Meadow Brook wetlands do not receive

surface drainage from the site. The wetlands southeast of the site, situated between Woburn Street and Interstate 93, are within the Aberjona River watershed and can receive potentially contaminated runoff from the site. Between 1960 and 2004 the extent of both wetlands west and southeast of the site have been impacted by land filling and development activities.

The fracture trace analysis was performed on the Olin Chemical Superfund site and the area surrounding the site. The analysis was conducted using black-and-white aerial photographs acquired in 1963 and 1978. A total of eight fracture traces were identified.

The EPA Environmental Sciences Division, Landscape Ecology Branch in Las Vegas, Nevada, prepared this report for the EPA Region 1 Hazardous Waste Management Division in Boston, Massachusetts, and the EPA Office of Superfund Remediation Technology Innovation in Washington, D.C.

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INTRODUCTION

This report presents the results of five aerial photographic analyses of the former Olin Chemical Superfund site in Wilmington, Middlesex County, Massachusetts (Figure 1). These analyses include a historical photographic site analysis, a land use/land cover analysis, a site discovery inventory analysis, a wetlands/drainage analysis, and a fracture trace analysis. The Olin Chemical Superfund site covers approximately 20 hectares (50 acres) in a predominantly commercial/industrial area located approximately 1.6 kilometers (1 mile) south of Wilmington, Massachusetts (Figure 2). The site is bounded to the north by Eames Street, to the east and west by railroad tracks, and to the south by the Woburn corporate boundary. The region has gently rolling terrain and a shallow groundwater level such that wetlands are observed to the north, east, south, and west of the site. The site is at an elevation of approximately 27 meters (90 feet) above sea level (USGS, 1979).

Collateral information on the history of the site states the first manufacturing facility was constructed on the site in 1953. From 1953 to 1986 a chemical manufacturing facility operated at the site. The facility produced chemical blowing agents, stabilizers, antioxidants, and other specialty chemicals. Prior to 1970 all liquid wastes were discharged into unlined pits and an unlined man-made excavation called Lake Poly. In 1970 an acid treatment and neutralization system was added and lined pits were installed to replace the unlined pits and ponds. The waste treatment process created a calcium sulfate sludge that was periodically dredged from the lagoons and placed in an on-site landfill along the southern boundary of the property. Wastes were subsequently discharged to an inter-municipal sewer system that was completed in 1972 (EPA, 2008).

The focus for the historical photographic site analysis of the Olin Chemical Superfund site, as requested by EPA Region 1 Office, includes identifying the presence and location of:

1) storage/processing tanks, buried tanks, leach fields, piping, drum storage and handling areas, construction of and changes to buildings, structures, and paved areas. Within the photo analysis narrative these topics are addressed under the heading "Plant Operations",

2) waste handling and disposal activity at the site to include pits, ponds, lagoons, landfill, solid waste piles, soil/ground stains and vegetation stress areas. Within the photo analysis narrative these topics are addressed under the headings "Waste Disposal Activity", and

3) surface drainage patterns, ditches, discharge outfalls, and related drainage features to include ponds and wetlands. Within the photo analysis narrative these topics are addressed under the heading "Drainage Features".

Drainage features are also delineated and discussed in the wetlands/drainage analysis section of this report.

For the historical photographic site analysis seventeen dates of aerial photography were analyzed and ten dates (1952, 1960, 1965, 1971, 1978, 1980, 1984, 1991, 1995 and 2004) were selected for inclusion in this report. The findings of the historical photographic site analysis showed that the facility on the Olin Chemical Superfund site was active by 1960. At that time the facility operated numerous processing/storage tanks, processing buildings, a drum handling area, and liquid waste ponds/pits. Various waste pits, ponds, lagoons, and a landfill area were operated over the life of the chemical plant. By 1978 a landfill had been established near the southwestern corner of the site. The landfill was closed and recontoured by 1991. By 1991 several buildings and structures were dismantled and two lagoons had been closed and buried. By 2004 a large containment area had been constructed across an area formerly occupied by two lagoons that had been closed by 1991.

The land use/land cover, site discovery inventory, and wetlands/drainage analyses were performed for a study area that surrounds the Olin Chemical Superfund site. This study area is bounded to the east by Interstate 93, to north by Butters Row Road and Lowell Street, to the west by Chestnut Street and to the south by Merrimac Street. The land use/land cover, site discovery inventory, and wetlands/drainage analyses were performed using historical aerial photography dated 1960 and 2004.

Findings of the land use/land cover analysis determined that in 1960 the study area consisted of residential land, commercial and industrial land, wooded land with wetlands and ponds/lakes, agricultural land, and transitional land. By 2004 the both commercial land use and residential land use had significantly increased while agricultural land and wooded land had significantly been reduced. Between 1960 and 2004 the significant changes were generally due to man-made modifications to the natural landscape frequently associated with development. The establishment of the Olin Chemical facility, the creation of large municipal landfill operations (Spinazola Sanitary Landfill and Woburn Sanitary Landfill), the expansion of several commercial parks, and the construction of additional residences accounted for the largest changes in the land use/land cover.

The findings of the site discovery inventory analysis for the period 1960 and 2004 revealed the predominant development was in commercial retail, warehousing, and commercial services. Two large landfill operations were observed over the period 1960 through 2004. Analysis of the 1960 photography identified eight discovery sites and analysis of the 2004 photography identified 14 discovery sites.

Findings of the wetlands/drainage analysis indicated that the largest extent of wetlands is located west of the site along Maple Meadow Brook. The Maple Meadow Brook wetlands do not receive surface drainage from the site. The large area of wetlands, located southeast of the site, between Woburn Street and Interstate 93, is within the Aberjona River watershed and can receive potentially contaminated runoff from the site. The extent of both large wetland areas west and southeast of the site have been impacted by land filling and development activities.

The fracture trace analysis was performed on the Olin Chemical Superfund site and the area within an approximate two kilometer (1.2 mile) radius of the site. The objective of the fracture trace analysis was to identify zones of fracturing in the bedrock that could act as preferential pathways for subsurface contaminant flow. The findings of the analysis are based on the study of 1963 and 1978 black-and-white aerial photographs in conjunction with pertinent geologic literature (see References) of the site and surrounding area. A total of eight fracture traces were identified and are presented on Figure 20 (2004 photograph).

Features referenced in background or collateral material are cited in the text of this analysis. When first mentioned in the text, these features are denoted with an asterisk (*). They are also marked with an asterisk each time they appear on the photographs.

This report is presented in two volumes. Volume 1 contains the text of the report, including the introductory, methodological, and photographic analysis discussion sections. Volume 2 contains the various maps and the photographs, with respective annotated overlays.

A Glossary, defining features or conditions identified in this report, follows the Photographic Analysis section. Sources for all maps, aerial photographs, and collateral data used in the production of this report are listed in the References section. A list of all aerial photographs that were identified and evaluated for potential application to this study can be obtained by contacting the EPA Work Assignment Manager. Historical aerial photographs used in the analysis of this site have been digitally scanned and printed for use in this report. A transparent overlay with interpretative data is affixed to each of the digital prints. See the Methodology section for a discussion of the scanning and printing procedures.

The EPA Environmental Sciences Division, Landscape Ecology Branch in Las Vegas, Nevada, prepared this report for the EPA Region 1 Hazardous Waste Management Division in Boston, Massachusetts, and the EPA Office of Superfund Remediation Technology Innovation in Washington, D.C.

METHODOLOGY

This report was prepared using a standard methodology that includes the following steps:

- data identification and acquisition,
- photographic analysis and interpretation, and
- graphics and text preparation.

These steps are described below. Subsections also address details related to specific kinds of analyses that may be required to identify environmental features such as surface drainage and wetlands. All operational steps and processes used to perform this work (including data identification and acquisition, photographic analysis and interpretation, and graphics and text preparation) adhere to strict QA/QC guidelines and standard operating procedures (SOPs). These guidelines and procedures are documented in the Master Quality Assurance Project Plan (QAPP) prepared for Remote Sensing Support Services Contract No. EP-D-05-088 (LMS, 2006).

Data identification and acquisition included a search of government and commercial sources of historical aerial film for the study area. Photographs with optimal spatial and temporal resolution and image quality were identified for acquisition. In addition, U.S. Geological Survey (USGS) topographic maps were obtained to show the study area location and to provide geographic and topographic context.

To conduct this analysis, the analyst examined diapositives (transparencies) of historical aerial photographs showing the study area. Diapositives are most often used for analysis instead of prints because the diapositives have superior photographic resolution. They show minute details of significant environmental features that may not be discernible on a paper print.

A photographic analyst uses a stereoscope to view adjacent, overlapping pairs of diapositives on a backlit light table. In most cases, the stereoscope is capable of various magnifications up to 60 power.

Stereoscopic viewing involves using the principle of parallax (observing a feature from slightly different positions) to observe a three-dimensional representation of the area of interest. The stereoscope enhances the photo interpretation process by allowing the analyst to observe vertical as well as horizontal spatial relationships of natural and cultural features.

The process of photographic analysis involves the visual examination and comparison of many components of the photographic image. These components include shadow, tone, color, texture, shape, size, pattern, and landscape context of individual elements of a photograph. The photo analyst identifies objects, features, and "signatures" associated with specific environmental conditions or events. The term "signature" refers to a combination of components or characteristics that indicate a specific object, condition, or pattern of environmental significance. The academic and professional training, photo interpretation experience gained through repetitive observations of similar features or activities, and deductive logic of the analyst as well as background information from collateral sources (e.g., site maps, geologic reports, soil surveys) are critical factors employed in the photographic analysis.

The analyst records the results of the analysis by using a standard set of annotations and terminology to identify objects and features observed on the diapositives. Significant findings are annotated on overlays attached to the photographic or computer-reproduced prints in the report and discussed in the accompanying text. Annotations that are self-explanatory may not be discussed in the text. The annotations are defined in the legend that accompanies each print and in the text when first used.

Objects and features are identified in the graphics and text according to the analyst's degree of confidence in the evidence. A distinction is made between certain, probable, and possible identifications. When the analyst believes the identification is unmistakable (certain), no qualifier is used. Probable is used when a limited number of discernible characteristics allow the analyst to be reasonably sure of a particular identification. Possible is used when only a few characteristics are discernible, and the analyst can only infer an identification.

The prints in this report have been reproduced, either by photographic or computer methods, from the original film. Reproductions are made from the original film and may be either contact (the same size) prints or enlargements, depending on the scale of the original film. Any computer-produced prints used in this report are generated from scans of the film at approximately 1,300 dots per inch (dpi) and printed at 720 dpi. Although the reproductions allow effective display of the interpretive annotations, they may have less photographic resolution than the original film. Therefore, some of the objects and features identified in the original image and described in the text may not be as clearly discernible on the prints in this report.

Study area boundaries shown in this report were determined from aerial photographs or collateral data and do not necessarily denote legal property lines or ownership.

Digital Diapositives

Some film vendors no longer supply analog film products (e.g., diapositive transparencies) to their customers. Digital files, created by scanning the original analog film products, are provided. The digital file, a representation of an original analog film product, can be analyzed either by computer viewing techniques or by creating a secondary diapositive from the digital file and viewing the secondary diapositve on a light table. The result of this process of converting an analog diapositive image to a digital file may be a reduction in the photographic resolution. A potential consequence of this in the realm of aerial photographic analysis is a lower confidence in the identification of features or conditions of environmental significance. For example, what may have been identified with certainty as "a drum" on the analog version of the diapositive may, on the digital diapositive, only be determined to be "a probable drum."

Color Infrared Photographs

Some photographs used for this analysis were made from color infrared

film. Normal color film records reflected energy in the blue, green, and red portions of the electromagnetic spectrum. Color infrared film differs in that it is sensitive not only to reflected blue, green, and red energy, but also to reflected energy in the infrared portions of the electromagnetic spectrum; however, the blue energy is filtered out and only the green, red, and infrared energy is recorded. When color infrared film is processed, it displays "false" colors that do not correspond with the true colors of the features photographed. For example, features that are highly reflective in the infrared portion of the spectrum, such as healthy vegetation, appear red to magenta on color infrared film. The false color displayed by a feature is produced in accordance with the proportions of green, red, and infrared energy it reflects. These proportions are referred to as the "spectral reflectance characteristics" of the feature. To interpret the true color of a particular feature accurately from color infrared film, a knowledge of the spectral reflectance characteristics of that feature is required. This information is not readily available for the majority of features identified in this report. Therefore, unless otherwise indicated, no attempt has been made to interpret the true colors of the features identified on the color infrared film analyzed for this report.

Land Use/Land Cover Analysis

Land use/land cover analysis is conducted by analyzing aerial photographs in conjunction with the Anderson Classification System (Anderson 1976). The classification system is hierarchical in nature beginning with Level I, the broadest classification of land use/land cover types. Examples of these are residential, commercial, and industrial. Level II consists of more detailed categories of land use such as single versus multiple residential dwelling units. The classification scheme can be customized to create Levels III and IV depending on project requirements. Land use/land cover data are displayed on clear acetate overlays attached to photographs or USGS topographic maps.

Wetland Analysis

The most general type of wetland analysis involves differentiating wetland and nonwetland areas. An analyst utilizes aerial photographs, soil surveys, hydric soils data, National Wetland Survey maps, and other available data to identify wetland boundaries and drainage networks within a study area. More detailed analyses are conducted using the Cowardin Classification System (Cowardin 1979) to provide information regarding vegetation types and hydrologic regimes. Analyses of photography from several years can be compiled to assess changes in wetland areas and measurements can be conducted to quantify results. Field checking of final products can confirm and refine mapping results and aid in compliance with jurisdictional and legal requirements. Results of wetlands analysis are presented on clear acetate overlays attached to photographs or USGS topographic maps.

Fracture Trace Analysis

Fracture trace analysis is the technique for locating fractures traces or geologic lineaments on the earth's surface. Photographic signatures such as soil-tonal variations, and vegetational and topographic alignments are identified, analyzed, and compared to known cultural and geologic information to determine if the signatures are likely to be expressions of fractures in the bedrock. Results from the fracture trace analysis are presented on clear acetate overlays to photographs or USGS topographic maps.

Surface Drainage

The surface drainage analysis produced for this report identifies the direction and potential path that a liquid spill or surface runoff would follow based on the topography of the terrain and the presence of discernible obstacles to surface flow. The analyst determines the direction of surface drainage by stereoscopic analysis of the aerial photographs and by examining USGS topographic maps. Site-specific surface drainage patterns are annotated on the map or photo overlay. Where the

direction of subtle drainage cannot be determined, an indeterminate drainage line symbol is used. Regional surface flow is ascertained from the USGS topographic maps.

Photogrammetric Mapping/Measurements

Detailed photogrammetric mapping was conducted for the study site utilizing a Kern DSR 15 analytical stereoplotter (with dual head optics). This instrument is operated with AP32 analytical stereoplotter software.

HISTORICAL PHOTOGRAPHIC ANALYSIS

The Olin Chemical Superfund site is located approximately 1.6 kilometers (1 mile) south of Wilmington, Massachusetts. The site is approximately 20 hectares (50 acres) in size and in 2008 was located in a commercial/industrial area. The site occupies a trapezoid-shaped area and is bounded by Eames Street to the north, railroad lines to the east and west, and to the south by the political border between the towns of Woburn and Wilmington. The railroad along the western perimeter of the site is on a raised bed. The northern portion of the railroad that runs along the eastern perimeter of the site is below grade.

Within this historical photographic analysis narrative of the Olin Chemical Superfund site three specific topics of focus are discussed:

Plant Operations - includes the presence and location of storage/processing tanks, buried tanks, leach fields, piping, drum storage and handling areas, construction of and changes to buildings, structures, and paved areas.

Waste Disposal Activity - includes waste handling and disposal activity at the site to include the presence and location of pits, ponds, lagoons, landfills, solid waste piles, soil/ground stains, and vegetation stress areas.

Drainage Features - includes surface drainage patterns, ditches, discharge outfalls, and related drainage features to include ponds and wetlands.

OCTOBER 12, 1952 (FIGURE 3)

Plant Operations - The site contains undeveloped wooded land. There are no buildings or structures on the site. Neither railroad line adjacent to the site has a spur that serves the site. Vehicle access into the site is from the north via an unpaved road from Eames Street.

Waste Disposal Activity - There is no waste handling activity at the site.

Drainage Features - A natural drainage channel, partially obscured by tree cover, trends southeast across the center of the site. Surface runoff from the site trends southeast and reaches the East Ditch*. The East Ditch has been dug along the western side of the railroad (R/R) that delimits the eastern side of the site. The East Ditch flows to the south into a culvert under the railroad and into another ditch that empties into the North Pond on the eastern side of Woburn Street. There are two areas of low, flat terrain that lack tree cover; one in the northwestern corner of the site and one in southwestern corner of the site. These two areas are possible wetland areas.

Offsite Features - Scattered houses are located to the east and west of the site. Industrial facilities (not annotated) are noted on the northern side of Eames Street adjacent to the site. Disturbed ground (DG) is also observed north of the site indicating probable construction activity. An industrial facility (not annotated) with an impoundment (IM) is observed southeast of the site. South of the site, parallel to the southern perimeter, is a drainageway that trends southeast. A pond is visible within this natural drainageway and near an impoundment located south of the site.

MAY 5, 1960 (FIGURE 4)

Plant Operations - A chemical facility, composed of Plants A* and B*, is under construction in the northern portion of the site. Plant A occupies the western and southeastern portion of the chemical facility and contains four buildings (B1 through B4). Plant B occupies the northeastern portion of the chemical facility and includes buildings B5 and B6, and a group of four horizontal tanks (HT) located near the eastern perimeter of the site. The four storage tanks, linked to buildings B5 and B6 via elevated pipelines, are inside a secondary containment revetment. The roadway into the site, noted in 1952 (Figure 3), has not been paved. Several (VEH) vehicles are present within the chemical facility. The ground surface around the majority of buildings is covered the light-toned soil and probably not paved.

Waste Disposal Activity - Within Plant A three rectangular-shaped waste pits/ponds have been constructed south of building B4. Dark-toned liquid (DTSL) is observed in the westernmost waste pit/pond, referenced as Lake Poly*. Pit-1 and Pit-2 appear to be dry. A bottom-lining material is not discerned within any of these pits/ponds.

Drainage Features - A network of connecting ditches carries surface flow southeastward across the site into the surrounding natural drainage system. The West Ditch* flows adjacent to Lake Poly and carries surface flow southward into the South Ditch*. A large erosion rill/breach observed along the western containment berm of Lake Poly suggests that liquid waste has been released into the West Ditch. The South Ditch, which does not appear to be channelized, flows into the East Ditch. Surface drainage is then directed offsite via a culvert under the railroad to eventually reach the North Pond and the natural drainage system.

Offsite Features - Since 1952 the ponds noted in the natural drainageway south of the site appear larger.

MAY 12, 1965 (FIGURE 5)

Plant Operations - The chemical facility is operating. Additional construction has occurred at Plant A. Four support buildings (SB1 through SB4) have been erected along with a parking lot. The parking lot, located at the north entrance to the site, has not been paved. An unfinished building foundation is observed east of building B1. A railroad spur, which enters the site from the western side, has been constructed. Buildings B1 and B2 have been joined together and building B7 has been constructed west of building B6. A group of processing tanks is on the eastern side of building B4. Building B8 has been built on the area formerly occupied by the closed and filled Pit-2. Elevated pipelines are observed linking building B3 to B5, and building B4 to B6 (not annotated). Within Plant B two horizontal storage tanks have been added to the group of tanks west of building B5 making a total of six tanks. All of these tanks are inside a secondary containment structure and are connected by pipelines. In addition one vertical storage tank (VT) has been constructed to the south of the group of six tanks. A pipeline (not annotated) connects building B6 to this tank. This vertical storage tank lacks a secondary containment structure. There is a separate horizontal tank (not annotated) with a pipeline (not annotated) to building B5. Also at Plant B a probable drum handling area is situated near the eastern side of building B5. Possible spillage is noted around the probable drum handling area.

Waste Disposal Activity - Liquid waste disposal activity continues south of Plant A. Lake Poly continues to contain liquid. Pit-2 has been closed and filled; building B-8 is now at this location. A dark-toned ground stain (DTST) is visible near the southwestern end of Pit-1. Pit-1 appears to be in use and nearly filled; however, an erosion rill/possible breach is noted on the western berm of the pit. A pipeline links Pit-1 to building B7.

Light-toned material (LTM) has been dumped south and southeast of building B8, and also near Central Pond*. An open waste area, located near the western rim of Lake Poly, contains debris (DB) and probable solid waste (SW).

Drainage Features - Deep erosion rills (not annotated) remain visible along the western berm of Lake Poly suggesting a lack of good housekeeping or maintenance of the berm and the containment integrity of Lake Poly. The channel of the South Ditch is obscured from view by the dense vegetation. A partial blockage of the South Ditch appears to have formed a body of liquid, referenced as Central Pond.

Offsite Features - Since 1960 an open storage yard, containing equipment and vehicles, has been established offsite on the eastern side of the railroad next to the eastern perimeter of the site. As a result of the establishment of the storage yard, the drainage ditch noted in 1960, is no longer visible. The ditch appears to have been channelized into a culvert (not annotated) that empties into the North Pond.

JULY 6, 1971 (FIGURE 6)

Plant Operations - The chemical facility remains active. Additional processing buildings, production units, and storage tanks have been constructed at Plant A. A roof (not annotated) has been added to the eastern side of building B4. The roof likely covers from view the group of processing tanks noted on the eastern side of building B4 in 1965. Building B9 has been completed where a foundation was observed in 1965. Since 1965 the orientation of the railroad spur serving the chemical facility has been changed to run along the western side of building B8. Building B8 was enlarged (not annotated) and buildings B10 and B11 were constructed. Plants A and B both operate several elevated pipelines that connect buildings to processing units and/or storage tanks. A new group of three horizontal storage tanks and one vertical tank, located to the east of building B11, are connected to building B11 via an elevated pipeline. These storage tanks appear to lack secondary containment. A group of nine vertical processing/settling tanks has been installed along the southern end of building B10 and are linked to the building via a pipeline (not annotated). The pipeline that linked building B7 to Pit-1 is not discerned and may have been removed.

Waste Disposal Activity - Liquid waste disposal activity continues on the site. Since 1965 Lake Poly and Pit-1 have been closed, filled, and graded. Light-toned material covers the surface of the former location of Lake Poly and debris continues to be visible near this location. The former location of Pit-1 is now occupied by a portion of building B10 and the adjacent settling tanks. Two earthen-bermed disposal pits/lagoons containing liquid, referenced as the West Acid Pit* and the East Acid Pit*, are located south of building B10. A bottom-lining material could not be discerned within these pits. An earthen-bermed pit that contained liquid was visible west of the West Acid Pit in 1970 (1970 aerial photography was analyzed but not produced in this report).

At Plant B a berm has been built on the eastern side of the large vertical storage tank situated east of B6. A ground stain is observed between this berm and the vertical storage tank. A mound of dark-toned

mounded material is observed northeast of building B11. A probable disposal trench (TR) has been dug on the southern side of B11.

Drainage Features - The West Ditch continues to direct flow along the western side of Plant A. The drainage patterns and conditions on the site do not appear significantly changed since 1965.

Offsite Features - South of the southern perimeter of the site, solid waste disposal operations of the Woburn Sanitary Landfill are evident. Several ponds noted in 1965 have been filled, likely as a result of the Woburn Sanitary Landfill operations.

APRIL 23, 1978 (FIGURE 7)

Plant Operations - The chemical facility remains active. The vertical tank north of building B11 and three horizontal tanks east of building B11 have been removed. No significant new construction is noted at the facility since 1971.

Waste Disposal Activity - The probable trench noted southeast of building B11 since 1971 is not discerned. The debris noted near the western side of the chemical facility adjacent to the West Ditch is not discerned; crates are now stored at this location. The liquid waste disposal structures, the West Acid Pit and the East Acid Pit, have been modified. Two large new lagoons (LG1 and LG2), each with containment berms, have been constructed south of buildings B8 and B10. The lagoons extend into the central section of the site and each lagoon has an approximate area of 0.3 hectares (0.8 acres). Lagoons LG1 and LG2 are in proximity to Central Pond and the South Ditch.

Poor housekeeping practices, observed at the chemical facility, reveal a lack of maintenance. The secondary containment dike serving the group of six horizontal storage tanks east of building B5 is full of dark-toned liquid, leakage, or spillage. Erosion rills next to this dike suggest it has overflowed. A large ground stain, next to the vertical storage tank south of the group of six horizontal tanks, suggests additional spillage or leakage has occurred. Standing liquid, visible southeast of this vertical storage tank, may be the result of spillage or leakage.

A large mound of light-toned material, deposited at the southwestern corner of the site, covers an area of approximately 1.3 hectares (3.3 acres). This dump area is termed the calcium sulfate landfill*. The calcium sulfate landfill does not appear to be associated with the adjacent Woburn Sanitary Landfill. The chemical facility, including lagoons LG1 and LG2, are linked to this calcium sulfate landfill via a dirt road that runs along the abandoned railroad track on the western side of the site. The dirt road appears to have been used to transport material from lagoons LG1 and LG2, and deposited at the calcium sulfate landfill.

Drainage Features - The leaf-off conditions of the trees along the western perimeter of the site enables the identification of a drainage culvert under the railroad that carries drainage into the site. This feature was not discerned and annotated on earlier dates of photography. This drainage flows southeast into the South Ditch.

Offsite Features - South of the southern perimeter of the site, solid waste disposal operations and filling operations (FL) continue at the Woburn Sanitary Landfill. The natural drainageway in this area has been filled as a result of dumping and landfill operations at the Woburn Sanitary Landfill.

NOVEMBER 6, 1980 (FIGURE 8)

A discussion of the aerial photographic interpretation findings for the southern section of the Olin Chemical Superfund site and offsite areas are presented here. The findings for the remainder of the site are presented in the text discussion for Figure 9.

Waste Disposal Activity - The dirt road continues to be used to traverse between the landfill and the lagoons LG1 and LG2 on the Olin Chemical Superfund site. Additional dirt roads that connect to Main Street/State Route 38 may also provide access to the calcium sulfate landfill. The calcium sulfate landfill remains active and the amount of mounded material dumped at the calcium sulfate landfill has increased since 1978. The mound of deposited material rises to its greatest height along its eastern side.

Photogrammetric measurement techniques were used to calculate the amount of material that had been deposited on the calcium sulfate landfill by 1980. The procedure used to produce the calculations included spot elevations (the elevation of one point on the surface) and breaklines (defining the break between two surfaces with different slopes) associated with a specific waste pile of calcium sulfate present on the 1980 aerial photographs. Ground control points (X, Y, & Z) for the Olin Chemical Facility, Wilmington, Massachusetts were acquired for the photogrammetric mapping effort from a USGS National Elevation Data set (NED) digital elevation model (DEM) dated February 1, 1999 to February 1, 2009, and a USGS High-resolution orthoimage dated April 2005 with a 1.64-foot pixel resolution. Volumetric calculations were performed using the mapped elevation data from the 1980 aerial photographs utilizing Cardinal Systems VR2 volumetric software. The photogrammetrically-derived measurements of the calcium sulfate landfill as it appeared on November 6, 1980 are:

Volume Totals	55.47 cubic meters (72,551 cubic yards)
Perimeter	277.5 meters (910.43 feet)
Area	4572 sq meters (49696.93 square feet)
	0.45 hectare (1.14 acres)

A visual representation of the mound of material on the calcium sulfate landfill, looking from the southeast, is presented on an inset to Figure 8. The figure was produced using the photogrammetric data that was used to derive the volume and area calculations.

Offsite Features - Waste disposal operations are ongoing at the Woburn Sanitary Landfill south of the site.

NOVEMBER 6, 1980 (FIGURE 9)

The 1980 low altitude, stereo, color photograph provides greater photographic resolution compared to the earlier photo coverages used in this analysis, consequently the 1980 photograph allows the identification of features within the site not discerned or described on the earlier dates of photography.

Plant Operations - The chemical facility remains operational. No significant new construction is observed at Plants A or B since 1978. Several elevated pipelines that were not previously discerned on earlier dates of photography are identified and annotated. Several vertical storage/processing tanks are now discerned along the northern and southern sides of building B4.

Waste Disposal Activity - The elevated pipelines do not show visible signs of leakage or spillage and good housekeeping is indicated. Good maintenance practices are lacking at Plant B where six horizontal and one vertical storage tank are concentrated east of building B5. Ground stains, disturbed ground, and areas of dead trees are visible on the southeastern side of Plant B and the southeastern side of Plant A (not all annotated). Also at Plant B a probable source of spillage/leakage is the secondary containment dike around the group of six horizontal storage tanks east of building B5. Ground stains are visible both inside and outside the dike. Visible erosion rills on the dike suggest the dike contents may have exited the secondary containment system. Ground stains and spillage are also visible on the pavement along the northern and eastern sides of building B6. Spillage/leakage is noted at the base of a tall vertical tank that lacks secondary containment located south of building B6. An area that contains mounded material/possible solid waste is observed to the east of the tall vertical storage tank located south of building B6. A large curbed drum handling area is on the eastern side of building B11. There are 200 or more 55-gallon drums (DR) in this area.

Liquid waste handling operations continue at the two large disposal lagoons (LG1 and LG2) located south of buildings B8 and B10. A pipeline

links lagoons LG1 and LG2. The earthen containment berm along the southern side of lagoon LG1 and eastern side of lagoon LG2 appears scarred with weathering erosion rills (not annotated).

Drainage Features - The West Ditch continues to flow in proximity to lagoon LG2 and reaches the South Ditch via a culvert. There are no significant changes in the drainage patterns of features within the site.

AUGUST 22, 1984 (FIGURE 10)

Plant Operations - The chemical facility remains operational. No significant construction or dismantling activity is noted at Plant A and B since 1980. Several vehicles are in the parking lot and truck trailers are observed at building B10. The rail spur has been removed. Additional piping is observed at Plant B serving the group of six horizontal storage tanks east of building B5. The additional piping appears to go east away from the chemical facility and toward the eastern perimeter of the site. The drum handling area on the eastern side of building B11 is partially obscured by a shadow. There appear to be fewer 55-gallon drums compared to those observed in 1980. The drums that are visible appear to be stacked on their sides.

Waste Disposal Activity - Liquid waste disposal operations continue at the southern side of the building B10 where lagoons LG1 and LG2 appear to be operational and well maintained. A bottom lining material is not discerned in either lagoon. A white-colored solid material (not annotated) has spilled on the southern side of the group of settling and vertical storage/processing tanks on the southern side of building B10. A tank truck is parked next to the spill area. A fenced area, possibly a salvage yard containing probable derelict horizontal and vertical tanks, pipes, and/or salvage metal (all features are not annotated), has been established on the southern side of building B11. The tanks in this fenced area do not appear to be in service as no piping is noted connecting to these tanks. The calcium sulfate landfill appears closed, contoured, and revegetated (REVEG).

Drainage Features - Much of the channel of the West Ditch has become overgrown with vegetation; however, the ditch does not appear to have been filled or modified.

MAY 16, 1991 (FIGURE 11)

Plant Operations - The chemical facility is no longer active. Since 1984 a large portion of Plant A has been dismantled. One vehicle is noted at the parking lot. Several building foundations (F) are visible where processing buildings and support buildings have been removed. The only remaining buildings at the former chemical facility are the support building SB1 and processing buildings B1, B2, B8, B9, and B10. There has been new construction at Plant B at the location of the group of horizontal storage tanks east of former building B5. Four horizontal tanks remain but two tanks are no longer visible; these tanks may have been removed or are under the roof of new building B12. Two vertical tanks have been placed on the northern side of building B12. Piping connects the tanks in this group. The one vertical tank directly south of the group of horizontal tanks appears to remain in service. A probable hose extends from a shed near the vertical tank, across the facility, and into the West Ditch west of building B8. Other vertical tanks noted at the chemical facility in 1984 have been dismantled, except for the group of settling tanks south of building B10.

Waste Disposal Activity - Lagoons LG1 and LG2 have been filled and graded. A grassy area occupies the former location of the waste lagoons. The calcium sulfate landfill in the southwestern corner of the site is contoured, revegetated, and occupies approximately 1.6 hectares (4 acres). The closed landfill appears larger in size then it appeared in 1984. Additional material was dumped at this location between 1984 and 1987 (1987 photographs were analyzed but not included in this report). The landfill was recontoured and revegetated between 1987 and 1991.

Drainage Features - The drainage pattern annotations of the West Ditch and South Ditch are approximate as the ditches are obscured from view by vegetation. Neither ditch appears to have been dammed, and runoff continues to trend southeast and leave the site. There are no significant changes in the drainage patterns within the site.

MARCH 29, 1995 (FIGURE 12)

Plant Operations - The chemical facility appears to be inactive. The storage tanks observed near building B12, as late as 1991, are not discerned. The parking lot appears vacant. The probable hose observed in 1991 that connected Plant B to the West Ditch has been removed.

Waste Disposal Activity - No waste disposal activity is discerned.

Drainage Features - The course of the West Ditch is generally overgrown but its pattern can be partially discerned through the wooded area in the central portion of the site. There are no significant changes in the drainage patterns or features within the site.

JULY 4, 2004 (FIGURE 13)

Plant Operations - The chemical facility remains inactive and the parking lot is vacant. Several building foundations are noted south and southeast of building B2. An area of disturbed ground is visible north of building B8. Since 1995 the group of settling tanks located south of building B10 has been dismantled.

Waste Disposal Activity - No active waste disposal activity is discerned. The calcium sulfate landfill remains capped and inactive. Since 1995 a containment area that occupies approximately 1.8 hectares (4.5 acres) and is covered with a dry, gray-colored material has been constructed south of building B10. As late as 1987 this location was occupied by lagoons LG1 and LG2. A curved containment wall delimits the southern and eastern sides of the containment area. A liquid-holding impoundment is located on the southern side of the curved containment wall.

Drainage Features - The West Ditch is no longer discerned reaching the South Ditch, the likely consequence of the construction of the containment area and the containment wall. Vegetation overgrowth precludes observing much of the South Ditch; however, no earthmoving activity is noted to suggest the course of South Ditch has been modified. The revegetated calcium sulfate landfill mound blocks a natural drainageway and a body of standing liquid has accumulated along its western side.

Offsite Features - The Worburn Sanitary Landfill has been closed, contoured, and revegetated.

LAND USE/LAND COVER ANALYSIS

The land use/land cover analysis of the Olin Chemical Superfund site study area was performed to document changes to the pattern of land use/land cover. The land use/land cover study area extends approximately one mile from the center of the Olin Chemical Superfund site. Roadways were used when practical to delimit the study area boundaries because of the ease of locating these features consistently on historical dates of photography. The resulting irregular-shaped study area is bounded to the east by Interstate 93, to north by Butters Row Road and Lowell Street, to the west by Chestnut Street, and to the south by Merrimac Street.

The land use/land cover analysis used historical aerial photography dated 1960 and 2004 (Figures 14 and 15). The land use/land cover classification is based on a simplified Anderson Level II methodology. The observed land use/land cover classification categories found within the study area are presented in the following Table 1 and land use/land classifications are annotated on overlays.

Table 1. Level II Olin Chemical Superfund site land use/land cover classification scheme.

Urban		
	11	Residential
	12	Commercial and Services
	13	Industrial
	14	Utilities
	17	Other Urban
Agricultural Land		
	21	Cropland and Pasture
Forest Land		
	43	Mixed Forest Land
Water		
	52	Lakes
Wetland		
	61	Forested Wetland
	62	Non-Forested Wetland
Barren Land		
	75	Strip Mines, Quarries, and Gravel Pits
	76	Transitional

Findings of the land use/land cover determined that by 1960 the study area consisted of predominately undeveloped wooded land, wetlands, residential land use, and a limited amount of industrial or commercial land use. Between 1960 and 2004 the significant changes were generally due to man-made modifications to the natural landscape frequently associated with development. The establishment of the Olin Chemical facility, the creation of large municipal landfill operations (Spinazola Sanitary Landfill and Woburn Sanitary Landfill), the expansion of several commercial parks, and the construction of additional residences accounted for the largest changes in the land use/land cover. By 2004 the Olin Chemical facility was closed and partially dismantled. The Woburn Sanitary Landfill had been closed and revegetated. Across the study area commercial and residential development projects had replaced large sections of the undeveloped wooded land and wetlands observed in 1960.

SITE DISCOVERY INVENTORY

The discovery inventory of the Olin Chemical Superfund site study area was conducted to identify significant environmental features/conditions such as commercial or industrial facilities that are potential sources of contamination entering the soil and/or groundwater. The study area is bounded to the east by Interstate 93, to north by Butters Row Road and Lowell Street, to the west by Chestnut Street, and to the south by Merrimac Street. This analysis was conducted by reviewing two years of photography (1960 and 2004). Annotated polygons that delineate the discovery sites are placed on the respective photo figures (Figures 16 and 17). A brief description of the discovery sites follows.

Analysis of the 1960 photography identified eight discovery sites that are listed below along with environmentally significant features associated with each site. The sites include commercial and industrial facilities that contain either handling, storage, or disposal areas for waste, tanks, or drums that pose a potential spill threat to the natural drainage system.

Site 1 - Olin Chemical Superfund site: a detailed discussion is presented in the Historical Photographic Analysis section of this report.

Site 2 - Storage yard: houses probable crates/boxes, containers in proximity to a drainage ditch that empties into the North Pond.

Site 3 - Industrial facility: probable materials processing plant with storage silos.

Site 4 - Industrial facility: large parking area, storage tank farm, no waste handling or disposal facilities.

Site 5 - Industrial facility: several connected processing buildings, two storage tanks, small parking area, no waste handling or disposal facilities.

Site 6 - Industrial facility: served by railroad spur, several connected processing buildings, small parking area, light-toned probable solid waste dump, liquid holding impoundment.

Site 7 - Woburn Sanitary Landfill: exposed solid waste, debris.

Site 8 - Industrial facility: large processing buildings, storage tanks, liquid waste lagoons or ponds, dump area for light-toned material.

Analysis of the 2004 photography identifies 14 commercial, industrial, or municipal facilities that contain either handling, storage, or disposal areas for waste, tanks, or drums that pose potential spill threat to the natural drainage system.

Site 1 - Olin Chemical Superfund site: a detailed discussion is presented in the Historical Photographic Analysis section of this report.

Site 2 - Probable salvage/recycling operation: crates/boxes, containers, drums, storage buildings.

Site 3 - Industrial facility: probable materials processing, additional silos and support building constructed.

Site 4 - Industrial facility: large parking area, storage tank farm, no waste handling or disposal facilities, additional support building constructed.

Site 5 - Industrial facility: plant building expanded since 1960 with several additional connected processing buildings constructed and large paved parking areas established, the storage tanks noted in 1960 have been dismantled.

Site 6 - Industrial facility: served by railroad spur, several connected processing buildings, the light-toned probable solid waste dump and liquid holding impoundment have been removed.

Site 7 - Woburn Sanitary Landfill: dumping has ceased; the landfill has been closed, contoured, and revegetated; mounded material and earthmoving equipment are present in the southeastern corner of site.

Site 8 - Industrial facility: large processing buildings and storage tanks.

Site 9 - Wastewater treatment plant: two treatment lagoons.

Site 10 - Road construction and maintenance facility: earthmoving equipment, fuel storage tanks, and ground stains.

Site 11 - The Spinazola Landfill: appears closed but the cap does not appear completed, the bare earth cover soil has not been reseeded.

Site 12 - Probable automobile junkyard/salvage operation: derelict car bodies.

Site 13 - Manufacturing facility: storage tanks.

Site 14 - Probable sanitary landfill: probable closed disposal trenches.

WETLANDS/DRAINAGE ANALYSIS

Of particular concern to EPA Region 1 are changes to natural features, orientation of surface water features, wetlands, and wetlands extending into Maple Meadows Brook. The drainageways of particular concern are the West Ditch, East Ditch, South Ditch, New Boston Drainageway, and North Pond. The wetlands/drainage analysis of the Olin Chemical Superfund study area was performed to help address these concerns. The study area is bounded to the east by Interstate 93, to north by Butters Row Road and Lowell Street, to the west by Chestnut Street, and to the south by Merrimac Street.

The wetlands/upland analysis (see Methodology section) of the study area is based on historical aerial photographic interpretation, using photography dated 1960 and 2004. Collateral data in conjunction with aerial photographs were used to develop wetland identification characteristics specific to the Olin Chemical Superfund site and surrounding study area. The collateral data included land cover data (National Landcover Data); wetland data (National Wetland Inventory) and (Massachusetts Office of Geographic and Environmental Information, Department of Environmental Protection); and soil data sets (United States Department of Agriculture).

Findings of the wetlands analysis show that wetlands were located throughout much of the study area. Two large areas of wetlands were located west and southeast of the Olin Chemical Superfund site. The western area is located along Maple Meadow Brook and is situated west of Main Street/State Route 38 and east of Chestnut Street in both 1960 and 2004. These wetlands are in the Ipswich River watershed and do not receive surface drainage from the Olin Chemical facility. Those wetlands located southeast of the study site, situated between Woburn Street to the west and

Interstate 93 to the east, are within the Aberjona River watershed and do receive potentially contaminated runoff from the Olin Chemical facility.

Between 1960 and 2004 the spatial extent of wetlands in the study area have been impacted by land filling and development activities. The earthmoving has filled lowlands, dammed or impeded the natural drainageways, which have in several instances formed standing water bodies or enlarged wetlands.

Findings of the drainage analysis, which was conducted using 1960 and 2004 aerial photography, determined the Olin Chemical Superfund site is situated near the divide of two watersheds, the Ipswich River watershed, to the northwest of the site, and the Aberjona River watershed, to the southeast of the site.

Drainage originating west of the site in the area of Main Street/State Route 38 is unlikely to reach or impact the Olin Chemical facility as it flows north into Maple Meadow Brook, a tributary of the Ipswich River.

Drainage originating west of the site, in the area east of Main Street/State Route 38 and south of Eames Street, flows onto the site, via a culvert under the railroad, and then into the South Ditch. The southeast trending South Ditch carries flow across the site to the East Ditch. The East Ditch has been dug along the western shoulder of the railroad that runs parallel to the eastern side of the site. The East Ditch trends southeast and eventually reaches the North Pond via another ditch and culvert (see Figures in the Historical Photographic Analysis section of this report for detailed delineations of this drainage).

North Pond is situated southeast of the site. Between 1960 and 2004 the size of North Pond has been significantly reduced as a result of filling activity resulting from commercial development along New Boston Street, Industrial Way, and Presidential Way (see Figures in the Site Discovery Inventory and Land Use/Land Cover sections of this report for detailed delineations of this urban development). The outflow from North Pond trends south to enter the New Boston Drainageway*, a south trending

tributary of the Aberjona River located east of New Boston Street (see Figures in the Historical Photographic Analysis section of this report for detailed delineations of this drainage).

Analysis of the historical natural drainage patterns reveals numerous alterations have occurred as a result of man-made development projects. Low terrain areas including wetlands have been filled and leveled in preparation for construction; drainages are channelized, straightened, and diverted via culverts. In other situations natural drainageways have been dammed, blocked, or impeded resulting in ponding or expansion of wetlands. Examples of modifications to the historic drainage pattern include the creation of Mill Pond Reservoir, filling and leveling the terrain for the construction of houses northwest of Merrimac Street, filling and leveling the terrain for the construction of commercial developments along Main Street/State Route 38 and Woburn Street, and the deposition at the Woburn Sanitary Landfill.

FRACTURE TRACE ANALYSIS

Fracture trace analysis is the technique of using aerial imagery for locating fracture traces or geologic lineaments on the earth's surface based on the photo-geologic signatures such as soil-tonal variations and vegetational and topographic alignments. Fracture traces are considered to be the surface expressions of vertical-to-near-vertical zones of fracture concentration in bedrock (see Methodology section). Fracture traces indicate the location of fracture zones that may provide avenues for increased groundwater flow and, therefore, areas of concentrated contaminant collection and flow.

The Olin Chemical Superfund site, located in Middlesex County, Massachusetts, is situated in the Seaboard Lowland Section of the New England Physiographic Province. The site and most of the area around the site are underlain by glacially deposited material (unconsolidated sand and gravel) that ranges in thickness from a few feet to approximately 125 feet. The chief aquifer in the area is located in this glacially deposited material and groundwater movement away from the site is principally through this highly permeable aquifer. The bedrock that underlies the aquifer is crystalline rock (gneiss, schist, and quartzite), the surface of which is highly irregular. There is little groundwater movement through the bedrock, due to a low primary porosity. Groundwater movement through the bedrock that does occur is through secondary openings (e.g., fractures) in the rock (see References section).

The fracture trace analysis was conducted due to concerns regarding groundwater contamination at and around the Olin Chemical Superfund site. The fracture trace analysis was conducted using large-scale photographs (1963 and 1978) as well as geologic literature describing the area. Findings are presented on an overlay to a print produced from a 2004 photograph (see Figure 20). A total of eight fracture traces were

identified in the study area and within an approximate two kilometer (1.2 mile) radius of the site. The fracture traces are clustered in two areas east and west of the Olin Chemical site in areas of abundant bedrock outcrops or shallow bedrock. The thick glacial deposits and urban development in the other areas on and around the site likely preclude identification of fractures traces in those areas.

GLOSSARY

Access Road - A paved or unpaved route of vehicular access.

Berm/Dike - An embankment of either natural or man-made materials that impounds liquids, solids or other materials, or controls flood waters.

Building (B) - A relatively permanent, essentially boxlike construction having a roof.

Dark- (DT), Medium- (MT), or Light-Toned (LT) - Tones of features in question are compared with the darkest and lightest tones of gray (if using B&W photography) on the print.

Debris (DB) - The remains of anything that can be identified as being broken down, destroyed, demolished, or dismantled.

Disturbed Ground (DG) - A rough area where the ground surface has been dug up or overturned.

Drums (DR) - Metal cylinders used for the storage, transportation, or disposal of materials.

Fill (FL) - Earth, stones, or other material that is used to build up the level of an area of ground.

Ground Scar (GS) - An area of bare soil, apparently the result of human activity.

Impoundment (IM) - A topographic depression, excavation, or diked area, primarily formed from earthen materials and designed to hold accumulated liquid.

Lagoon (LG) - A liquid containment area that is apparently used for waste storage, disposal and/or treatment. A lined lagoon has an artificial barrier or liner to prevent migration of waste material into the soil.

Landfill (LF) - A disposal facility which intermittently employs a cover material.

Material (M) - Raw or waste materials on or in the vicinity of the site.

Mounded Material (MM) - Piles of raw or waste materials on or in the vicinity of the site.

Open Storage Area (OS) - An area of open-air (outdoor) storage of containerized, raw or waste materials, within industrial or manufacturing sites.

Sand/Gravel Pit - A surface mine from which sand and/or gravel are extracted.

Solid Waste (SW) - Any discarded material other than fluids, including solid or semi-solid material resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

Stain (ST) - A residue or discoloration resulting from a spill, discharge, or removed/dispersed materials.

Standing Liquid (SL) - A small, shallow, temporary collection of liquid, not necessarily waste.

Tanks - Vertical tanks (VT), horizontal tanks (HT), pressure tanks (PT), tank farms, and solid waste management units. A large receptacle, container, or structure for holding liquid or gas.

Trench (TR) - A long, narrow excavation unrelated to drainage.

Wetlands - Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

REFERENCES

MAPS

Source[a]	Figure	Name	Scale	Date
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COLLATERAL INFORMATION

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AERIAL PHOTOGRAPHS

Photo source[a]	Figure[b]	Date of acquisition	Original scale	Film type[c]	Mission I.D.	Source frame #	EPIC ID #
USDA	3	10-12-52	1:20,000	B&W	DPQ	99,100	60672,60673
USGS[d]	4,14,16,18	05-05-60	1:30,000	B&W	AF-59-33	6956	DI0000223
USGS	-	04-29-63	1:24,000	B&W	VAQZ	77,78	60677,00059
NOS	5	05-12-65	1:24,000	B&W	C&GS	25	19278
NASA	-	07-00-70	1:40,000	CIR	UNK	39,40	60680,60681
USDA	-	10-29-70	1:40,000	B&W	DPQ-5LL	64,65	60689.60690
NOS	6	06-06-71	1:30,000	B&W	71L	6889,6890	149885,149886
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USGS	-	07-24-85	1:24,000	CIR	4390	1746	60705
USGS	-	04-27-87	1:56,000	B&W	HAP85	43	60703
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EPA	11	05-16-91	1:15,000	CIR	91028	91-028:21,22	-
USGS	12	03-29-95	1:40,000	B&W	NAPP	21,22	60714,60715
USDA[d]	13,15,17, 19,20	07-04-04	1:40,000	CC	NAIP04	95,96	DI0000234

[a]EPA U.S. Environmental Protection Agency, Environmental Sciences Division, Las Vegas, Nevada
NASA National Aeronautics and Space Administration, Houston, Texas
NOS National Ocean Service, Coast and Geodetic Survey, Washington, D.C.
USDA U.S. Department of Agriculture, Salt Lake City, Utah
USGS U.S. Department of Interior, U.S. Geological Survey, Washington, D.C.
[b]Photographs listed with no figure number were analyzed but not placed in this report.
[c]B&W Black-and-white
CIR Color infrared
CC Conventional Color
[d]Digital diapositive (see Methodology section)